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Name of invention : Prepreg of reinforced fiber fabric and its manufacturing method

Scope of patent claim :

Claim 1

A manufacturing method of wet type prepreg of reinforced fiber fabric characterized in that a reinforced fiber fabric composed of twist-free, flat reinforced fiber yarn with a yarn width of 3 to 20 mm, a ratio of yarn width to yarn thickness of 20 or above, a number of crossing points of warp and weft 2,500 to 25,000 per square meter and the cover factor 90% or more, is used and:

(1) a polymer binder is distributed line-like on the reinforced fiber fabric to glue the entire yarn width of the weft and/or warp,

(2) the reinforced fiber fabric is infiltrated in a solution of thermosetting resin diluted with solvent A, at least 80% of which is insoluble in the abovementioned polymer,

(3) then the solvent is dried by hot air.

Claim 2

The manufacturing method of wet type prepreg of reinforced fiber fabric according to claim 1, wherein the hot blow temperature for drying the solvent in the drying process from the start of drying to 1/4 of the drying zone is below the boiling point of the solvent.

Claim 3

The manufacturing method of wet type prepreg of reinforced fiber fabric according to claim 1 or 2, wherein, after drying the solvent, prepreg goes through calendar rolling.

Claim 4

The manufacturing method of wet type prepreg of reinforced fiber fabric described according to claims 1 through 3, wherein said binder is consisted of copolymer nylon soluble in alcohol and the abovementioned solvent A is consisted of non-alcohol type solvent.

Claim 5

The manufacturing method of wet type prepreg of reinforced fiber fabric described according to claims 1 though 3, wherein said binder is consisted of copolymer nylon insoluble in alcohol and said solvent A is consisted of alcohol type solvent.

Claim 6

The manufacturing method of wet type prepreg of reinforced fiber fabric according to claims 1 though 3, wherein said binder is consisted of polyester with a low melting point and the said solvent A is consisted of alcohol type solvent.

Claim 7

The manufacturing method of wet type prepreg of reinforced fiber fabric according to claims 1 through 6, wherein said binder is glued at least on the weft.

Claim 8

The manufacturing method of wet type prepreg of reinforced fiber fabric according to claims 1 through 7, wherein the binder consisted of said polymer is covered on the auxiliary yarn which has low heat contraction.

Claim 9

The manufacturing method of wet type prepreg of reinforced fiber fabric according to claims 1 through 8, wherein said resin is a thermosetting phenol resin.

Claim 10

The manufacturing method of wet type prepreg of reinforced fiber fabric according to claims 1 through 9, wherein said reinforced fiber yarn is a carbon fiber yarn.

Claim 11

The manufacturing method of wet type prepreg of reinforced fiber fabric according to claims 1 through 10, wherein an amount of the binder used is within 0.5 to 15 g/m^2.

Claim 12

Prepreg of reinforced fiber fabric obtained by any method described in claims 1 through 11, characterized in that it is composed of a twist-free, flat reinforced fiber yarn with a yarn width of 3 to 20 mm, a ratio of yarn width to yarn thickness of 20 or above, and the number of crossing points of the warp and weft is 2,500 to 25,000 per square meter and the cover factor is 90% or more.

Claim 13

Prepreg of reinforced fiber fabric according to claim 12, wherein said warp and weft are consisted of carbon fiber bundle with a number of filaments of 12,000 or more, a carbon fiber weight of 140 to 240 g/m^2 and weaving densities of the warp and weft are almost the same.

Claim 14

Prepreg of reinforced fiber fabric in claim item 12 or 13 wherein said resin is a phenol resin.

[Detailed description of invention]

[0001]

[Technical field to which the invention belongs]

This invention relates to prepreg and the manufacturing method of prepreg of reinforced fiber fabric used for forming fiber reinforced plastic (hereafter referred to as FRP).

[0002]

[Conventional technology]

FRP is formed by various methods. As a method of obtaining high performance FRP, the base fabric for forming is often used as prepreg made by pre-impregnating a sheet material such as fabric with a specified quantity of B stage resin containing hardening agent. There are two methods for manufacturing this prepreg: one is a dry processing method that is done by processing the resin in a film form and putting this upon the sheet material then heating and pressuring them to infiltrate resin into a sheet form, and another is a wet processing method that is done by diluting solid resin containing hardening agent or B stage resin with solvents of low boiling temperature such as methanol and MEK (methyl ethyl ketone) and drying this solvent after infiltrating resin into the sheet fabric. The dry processing method, as compared with the wet processing method, has such advantages as requiring no recovering of solvent or no management of residual dissolvent but it is hard to form film for some resin types. In some cases, hardening agents cannot get dispersed evenly throughput the resin, which makes the wet processing method, preferable for use.

[0003]

Usually, as thicker the yarn is, the reinforced fiber is cheaper. A flat fiber fabric, which has thin reinforced fiber, uniform fiber dispersion and a large cover factor, and its manufacturing method has been proposed in the official report of the Patent Publication 1995: No. 7-300739. Because this fabric is, as abovementioned, composed of flat warp and weft, and at the same time, is a thin fabric, yarn crimp is small and mechanical characteristic when FRP is performed is extremely excellent. However, because it is a thick yarn with small weaving yarn pitch, the number of

crossing points of warp and weft is small.

[0004]

As a form stabilizing measure in the prepreg processing, a low boiling point polymer was proposed to use as a binder for the fabric. When prepreg process was performed using such fabric, a good fiber dispersion in the fabric was secrured. In other words, we found that prepreg of a large cover factor can be obtained. However, the flat and fully wide warp and weft of the fabric, had its flatness crushed during the prepreg processing, resulting in mesh-like fabric with thin yarn. Observing how the flatness of yarn gets crushed during the prepreg process, we found that the flatness of weaving yarn is maintained throughout the process passing through the resin bath, diluted with a solvent, but a while after the fabric enters the drying zone, the flatness gradually begins to get crushed. On the other hand, in a case where the fabric prepreg maintains the flatness of weaving yarn, the flatness did not get crushed in the drying zone. In other words, it was found that binders not only improves handlability of fabrics during processes but maintains the flatness of weaving yarn of flat yarn fabrics during wet prepreg processing.

[0005]

[Issues this invention is trying to solve]

The object of this invention is to solve the abovementioned issues involved in the conventional technology and at the same time, based on the abovementioned information, to provide wet prepreg manufacturing method that can manufacture prepreg whose fiber dispersion is uniform, weaving yarn is flat and cover factor is large, as well as the prepreg manufactured by said method that has uniform dispersion, flat weaving yarn and a large cover factor.

[0006]

[Means to solve the issue]

To attain the above object, the manufacturing method of wet prepreg of reinforced

fiber yarn in this invention employs reinforced fiber yarn composed of twist-free, flat reinforced fiber yarn with a yarn width within the range of 3 to 20mm, a ratio of yarn width to yarn thickness of more than 20, the number of crossing points of the warp and weft of 2,500 to 25,000 per square meter and a cover factor of 90% or higher, and is consisted of the following method:

(1) polymer binder is distributed line-like on the reinforced fiber fabric and glued on the entire width of the weft and/or warp,

(2) infiltrating the relevant reinforced fiber fabric in a solution of thermosetting resin diluted with solvent A, at least 80% of which is insoluble in said polymer, and

(3) drying the solvent with hot air.

[0007]

Further, prepreg of reinforced fiber fabric, in this invention is composed of twist-free, flat reinforced fiber yarn with the yarn width in the range of 3 to 20 mm, a ratio of yarn width to yarn thickness of more than 20, the number of crossing points of warp and weft 2,500 to 25,000 and a cover factor of more than 90%.

[0008]

Further, to complete this invention, first, we observed the crushing phenomenon of the flatness, using a fabric composed of flat reinforced fiber yarn with the yarn width of 3 to 20 mm, a ratio of yarn width to yarn thickness more than 20, and the number of crossing points of 2,500 to 25,000 per square meter. Because this fabric has the number of crossing points one tenths to one twentieth of normal fabrics, the binding by weaving yarns of warn and weft loose, and no entanglement of fibers within the twist-free yarn bundle,

1) when such fabric resin is infiltrated in a solution diluted with a solvent and the solvent is dried, the resin viscosity of the solution glued to the fabric gradually increases and the surface tension of the solution acts toward inside of the width of the flat fiber yarn, in other words, acts in the direction narrowing the width of warp and weft, causing the flatness of fiber yarn to get crushed.

[0009]

2) Furthermore, drying of solvent in the wet prepreg process is performed to enhance the drying efficiency, but hot air passes through the void of fabric that exists slightly. This air passing through the void triggers a force to act in the direction of narrowing the yarn width of warp and weft, causing the flatness of fiber yarn to get crushed.

[0010]

3) Further, in case of vertical type drying furnace, the deadweight of the fabric and the weight of the solution are added to the fabric impregnated with resin at the upper part in addition to the supplying tension of fabric, and tension acts in the warp direction of fabric. With this tension, the crimped warp becomes straight and weft crimp becomes large. This change in the fabric structure, in other words, during crimp interchange, the weft acts in the direction of narrowing the warp width.

[0011]

Further, if binder is distributed line-like in the reinforced fiber fabric and glued to the entire yarn width of weft and/or warp, the fiber position gets fixed in the entire width of flat weaving yarn. In the wet prepreg processing, if the solvent is dried to a certain degree, the resin viscosity becomes large, so the gluing power between fibers becomes large due to high viscosity resin and even if a force of narrowing the yarn width as mentioned above occurs, the flatness of weaving yarn does not get crushed. However, at least it was found that as long as the solvent quantity is large and the resin viscosity is small, gluing force between fibers is weak and binding in the width direction of weaving yarn by binder is necessary.

[0012]

To satisfy these conditions, at least 80% of thermosetting resin should be diluted with solvent A insoluble in polymer, though it depends on the consumption quantity

of polymer as a binder. It was found that the entire solvent A should preferably be a solvent that is insoluble in polymer binder. Even if more than 80% of solvent is insoluble in polymer, in other words, if less than 20% is solvent B insoluble in polymer, the dissolving speed of polymer becomes slower and at least for about 3 to 5 minutes after the fiber passes through the resin bath and enter the drying zone, in other words, until the solvent is dissolved to a certain degree and the resin viscosity becomes large, binding in the width direction by the binder remains, so the flatness of weaving yarn does not get crushed. As solvents became less than 80% insoluble to polymer became, the flatness of weaving yarn gradually began to get crushed and void portions in the prepreg started increasing, causing fiber dispersion to be unequal, and the cover factor of obtained prepreg gradually declined.

[0013]

Here, the cover factor Cf, is an element related to the void portion where only the resin is filled with no reinforced fiber, in the gap formed between the weaving yarns of a fabric. If a territory of area S_1 is set up on the fabric or fabric prepreg, the area of the gap formed by the weaving yarns in the area S_1, or the area of the void where only the resin is filled with no reinforced fiber is S_2, the value defined by the following formula, is the cover factor.

[0014]

To add, if it is hard to measure the area of the void by prepreg, emit light from under the prepreg, then it is easy to classify the reinforced fiber portion and the portion where only the resin exists with no reinforced fiber.

Cover factor $Cf = [(S_1 - S_2) / S_1] \times 100$

[0015]

Further, the solvent quantity as a diluent for the resin is determined according to the setting of resin gluing quantity to the fabric and the solution viscosity should be set for the prepreg resin quantity to be 30 to 60 % of the weight.

[0016]
In this invention, it is not necessary to for the solvent to be solvent A which is 100% insoluble in polymer binder. Upon mixing a third component such as resin, hardener, or flame retardant, a slight amount of solvent B soluble in polymer binder can be used.

[0017]
In this invention, it is preferable for the binder to be a copolymer nylon with a melting point of about 100℃ to 140℃, and in particular, when it is FRPd, copolymer nylon of nylon 6 and nylon 12, copolymer of nylon 6, nylon 66 and 610, copolymer of nylon 6, nylon 12, 66 and 610, are preferable for their good resin gluing characteristic. In addition, because its melting point is low, it is easy to manufacture fabrics processed with binders. The melting point of copolymer nylon and solvent solubility are determined by the degree of nylon polymer crystallinity disarray at copolymerization, according to the combination of various said nylon polymers and mixing ratio, which means that some types of copolymer nylon can be soluble or insoluble in alcohol, such as methanol. Therefore, non-alcohol type, such as MEK, acetone, or toluene is used as solvent A for copolymer nylon soluble in alcohol.

[0018]
Here, solubility in this invention means the condition when polymer yarn, a binder, is placed in a beaker containing a solvent of 20℃, the yarn shape disappears forming a mass after it is left for 10 minutes, or, the yarn dissolves and no trace of yarn is seen. Insolubility means the condition of the yarn shape still remaining.

[0019]
Further, in this invention, methanol as the diluent of resin, is low in price, the boiling point is low, and drying at prepreg process is easy. For these reasons,

alcoholic type solvents, such as methanol is used as diluent, and low melting point polyester composed of copolymer polyester or insoluble copolymer nylon can be used as binder.

In addition, copolymer polyester, contains a specified amount of aliphatic dicarboxylic acids such as adipic acid and sebacic acid, aromatic dicarboxylic acids, such as phthalic acid, isophthalic acid and naphthalene dicarboxylic acid, and / or alicyclic dicarboxylic acids, such as hexahydro terephthalic acid and hexahydro isophthalic acid, and aliphatic and alicyclic diols, such as diethylene glycol and propylene glycol and is a copolymer ester added with oxyacid such as parahydroxyl benzoic acid and is a polyester obtained by adding and copolymerizing isophthalic acid and 1,6 - hexane diol to terephthalic acid and ethylene glycol.

[0020]

For binders in this invention, the abovementioned copolymer nylon and low melting point polyester are preferable, but other than above, low melting point polymers such as polyethylene and polypropylene can be used.

[0021]

Binders, essentially, do not form matrix resin of FRP, and become completely heterogeneous according to the resin used, so the amount should be as small as possible, preferably in the range of 0.5 to 15 g/m^2. When it is less than 0.5 g/m^2, binding of flat weaving yarn in the width direction becomes weak and during wet prepreg processing, it is impossible to prevent narrowing of the width of weaving yarn. Further, if it exceeds 15 g/m^2, FRP mechanical characteristic may deteriorate. If it is within the range of 0.5 to 15 g/m^2, narrowing of the width can be prevented, and mechanical characteristic of FRP may not deteriorate as much.

[0022]

Further, in this invention, because binders prevent narrowing of the width of weaving yarn, the amount of polymer per yarn distributed line-like is important. It

is preferable for the amount of polymer as binder to be in the range of 0.2 weight % to 2 weight % to the reinforced fiber yarn.

[0023]

[The form of implementation of invention]

The preferable implementation form of invention is described in the following, using drawings for reference.

Figure 1 shows one example of flat yarn fabric 1 for filling, used in the manufacturing method of wet prepreg of reinforced fiber fabric in this invention. The weaving yarn of the warp 2 and weft 3 is composed of the flat reinforced fiber yarns with the yarn width of 3 to 20 mm, the ratio of yarn width to the yarn thickness of more than 20, the number of the crossing points of the warp 2 and weft 3 being 2,500 to 25,000 per square meter and the cover factor being more than 90%.

[0024]

Here, the yarn thickness means, the thickness of yarn at the average value of N=10, obtained by reading the scale of a micrometer when the spindle is rotated quietly and the measurement side lightly contacts the sample surface for the ratchet to sound 3 times, in accordance with JIS-R3414, Section

[0025]

In Figure 1, binder 4 and binder 5 are glued line-like at the center of the yarn width in the two directions of the flat warp 2 and weft 3, and the warp and weft are glued at the crossing section to glue and bound the flat warp and weft with the binder for the entire width.

[0026]

Here, bonding direction does not necessarily have to be in the two directions of the warp and weft. It depends on the thickness of the weaving yarn, weaving density and binding degree of the weaving yarn. However, when the binder is glued to the

weft, the entire warp is bound by the binder, by which the change in the fabric structure by tension acting in the warp direction of fabric, in other words, narrowing of yarn width by crimp interchange can be prevented.

[0027]
It is not always necessary to position the binder at the center of the yarn width. It can be positioned slightly misaligned to the left or right of the weft width, for instance, it can be between the warp and warp of reinforced weaving yarns or between the weft and weft. Further, when the warp and weft are glued at their crossing part, the crossing point gets glued, stabilizing the fabric form. But this is not always necessary. It can be positioned between the warp and warp or between the weft and weft. It is not necessary to glue the warp and weft with a binder. If the binder is coated line-like on the entire width of the flat warp and weft, surface tension, hot air penetration, and narrowing due to crimp interchange can be prevented.

[0028]
In this invention, polymer does not have to be applied alone as a binder, but can be coated on the auxiliary yarn of low heat contractility.

[0029]
By winding fiber yarn made of polymer around an auxiliary yarn with low heat contraction by a covering method, and manufacturing a fabric using this together with the warp and weft of reinforced fiber yarn, and heating to a temperature above the melting point of polymer fiber to let melt, a fabric filled by coating the auxiliary yarn with polymer can be manufactured.

[0030]
By heating and melting at a temperature higher than the melting point of low melting point polymer and lower than the melting point of a high melting point

polymer after manufacturing a fabric using a core-sheath type multi-filament or mono-filament where the low melting point polymer used as a binder is the sheath and the high melting point polymer is the core, such as the sheath being a low melting point polymer with a melting point of about 160℃ to 200℃, and the core being a high melting point polyester polymer with a melting point of about 260℃, or the sheath being a low melting point polymer with a melting point of about 90℃ to 150℃, and the core being a high melting point polymer of polypropylene with a melting point of about 160℃ to 175℃, together with the warp and weft of a reinforced fiber yarn, a fabric filled by coating the auxiliary yarn with polymer can be manufactured.

[0031]

The low heat contractility auxiliary yarn means a yarn with the dry heat contractibility of less than 1.0% at 100℃, or preferably less than 0.1%. Glass fiber yarn or polyamide fiber yarn are preferable for the auxiliary yarn and thin yarns with the yarn size of 50 denier to 800 denier is preferable for the auxiliary yarn.

[0032]

Because the dry heat contractibility of core-sheath type polymer yarn is generally large, the core polymer yarn remains in a fiber form and contracts without melting when the low melting point polymer is heated for melting, causing the fiber width to be narrow, and the weaving yarn to zigzag. Therefore, yarns that had been heat treated to the dry heat contractibility of less than 1.0% should be used.

[0033]

If the binder polymer is coated with low heat contractibility auxiliary yarn, the binder is securely surrounded by the auxiliary yarn. This means that binder is distributed and glued securely on the entire width of the flat warp and weft line-like, which can prevent narrowing of the yarn width during the wet prepreg processing

more completely than when the binder is polymer alone.

[0034]

For the thermosetting resin used in this invention, epoxy resin, unsaturated polyester resin, vinyl ester resin or phenol resin are employed. Of these, for the manufacturing method of this invention, wet prepreg manufacturing method using phenol resin is preferable.

[0035]

One example of wet prepreg processing of this invention is illustrated in Figure 2. The solution 7 diluted with solvent is placed into the resin bath 6 installed at the bottom, and into this resin bath 26, rolled fabric 1 is infiltrated by drawing out at the speed of 1.5 m to 5 m per minute to impregnate resin between fibers of the fabric, and this is passed through the vertical dry furnace 9 having a dry zone of sufficient length and attached with a rotating roll 8 at the top. Additionally, though it differs according to the fabric type, drying speed, drying temperature, resin type, solvent type and resin glued quantity, the appropriate height for the vertical drying furnace is 8 m to 15 m and the appropriate length of the drying zone is 2-times the height of the drying furnace, in other words, about 16 m to 30 m, because the resin impregnated fabric is dried at two sides of the upward side and the downward side.

[0036]

Next, the fabric 1 glued with solution is drawn up linearly to the rotating roll 8 after passing through the resin bath 6, and hot air at the temperature A and B are blown in the rectangular direction to the fabric surface from the blowholes 11 and 12 at the wall 10 of the upward movement side of the fabric, drying the solvent to a certain degree, and then reversing the moving direction of the fabric by letting the fabric pass through the rotating roll 8, and hot air are also blown in the rectangular direction to the fabric surface from the blowholes 14 and 15 at the wall 13 of the downward movement side to dry the remaining solvent. In addition, it is

preferable for the number of hot air blowholes to be 2 to 4 at each side of wall 10, at the upward side, and wall 13, at the downward side, so hot air at different temperatures can be blown from each blowhole and control the drying condition of the solvent. Further, by attaching separator 36, at the center of the vertical drying furnace 29, parallel to the fabric surface, the drying temperature can be changed at the upward side and downward side of the fabric separately, enabling the temperature for each drying zone to be set correctly.

[0037]

By rewinding the solvent dried fabric along with a releasing paper 17, prepreg by wet processing method can be obtained.

[0038]

To add, when drying solvents mixed with two or more different types, the hot air temperature at the first half of the drying zone in the drying process should be below the boiling point of the solvent with the lowest boiling point. If this temperature exceeds the boiling point, the solution used to dilute the resin glued to the fabric foams during the drying of the solvent, and this force that produce foam disturbs the fiber configuration of weaving yarn and crushes the flatness of weaving yarn because the binding of weaving yarn by crossing of the warp and weft of flat yarn fabric is loosened and the yarn bundle has no entanglement between fibers within the twist-free yarn bundle, and depending on the fabric standard, the weaving yarn may get thin. Therefore, it is preferable for the hot air temperature in the process from drying start to at least 1/4 of the drying zone to be below the boiling point of the solvent. When drying progresses to a certain point, binding of fibers gets enhanced by the gluing characteristic of resin, so the temperature can be raised higher.

[0039]

In the wet prepreg method of this invention, fabric prepreg is inserted between a

lining film or a releasing paper after the solvent is dried, so the resin does not get glued to the roll. Then it is pressurized at the line pressure of 1.0 kg/cm to 50 kg/cm by a calendar roll heated to 80℃ to 150℃, to pass through at the feeding speed of 1m/minute to 5 m/minute, then, the yarn width of the warp and weft widens due to the weaving yarn being twist-free, prepreg with a flat weaving yarn with few crossing points, and a cover factor of 100% is obtained.

[0040]

The reinforced fibers used in this invention are those with a high strength and high elasticity, such as glass fiber, polyamide fiber and carbon fiber. Of these, carbon fiber with a tension elasticity of 200 GPa or higher and tension strength of 4,500 MPa or higher, is not only high in strength and high in elasticity but also has excellent impulse resistance. If the resin is a phenol resin, the carbon fibers do not get burned and shows excellent fire resistance. Furthermore, the filament quantity of carbon fiber yarn used is about 6,000 to 30,000 and it is preferable for carbon fiber area weight of the fabric to be about 140 g/m^2 to 400 g/m^2.

[0041]

Furthermore, this invention features prepreg of reinforced fiber fabric composed of twist-free, flat reinforced fiber with the yarn width of 3 mm to 20 mm, a ratio of yarn width to yarn thickness of more than 20, the number of crossing points of the warp and weft 2,500 to 25,000 per square meter and a cover factor of more than 90%.

[0042]

Because this is the fabric prepreg composed of the flat reinforced fibers with the yarn width of 3mm to 20mm, a ratio of yarn width to yarn thickness of more than 20, and the number of the crossing points of the warp and weft being small, i.e., 2,500 to 25,000 per square meter, it has an excellent drape characteristic. Furthermore, because it is a fabric consisted of twist-free, flat reinforced fiber yarn,

there is no squeezed part caused by twisting, and a fabric prepreg with a uniform void condition can be obtained. Furthermore, because the cover factor is more than 90%, a fabric prepreg with reinforced fiber dispersed uniformly can be obtained, and because the void area is small with no reinforced fiber, the mechanical characteristic is uniform with no void concentration, when it is formed into a composite material.

[0043]

The prepreg of reinforced fiber fabric obtained in this invention has such characteristic as the warp and weft being composed of carbon fiber bundle with the number of filaments more than 12,000, the weight of carbon fiber140g to 240g per square meter, and the weaving density of the warp and weft almost equal. It is a cheap prepreg because of its thin prepreg using few fiber of thick carbon fiber filament, and because it is a thin prepreg with a normal resin gluing quantity of 30 to 60 weight %, it is light.

[0044]

In particular, if the resin of this invention is a phenol resin, the FRP obtained is excellent in incombustibility, which make its preferable. And the prepreg of this invention has the number of crossing points of the warp and weft of 2,500 to 25,000 per square meter, the quantity of void parts where carbon fiber does not exist is less, and the cover factor is more than 90%, so the void area is small. This reinforced fiber is a carbon fiber and is excellent in fire resistance.

Such prepreg, in particular, blocks flame in the event of fire, and is preferably used as FRP reinforced material of a sandwich structure that consist the side wall, galley, toilet and floor panel in an aircraft. Further, it is preferably used as and interior material for trains and buses.

[0045]

[Example]

Using fabric A with a yarn width of 6.5 mm, ratio of yarn width to yarn thickness of 65, twist-free and flat, composed of carbon fiber bunch with a filament quantity of 12,000 and yarn density of the warp and weft 1.25/cm, the number of crossing points in a flat structure 15,600 per square meter, and the weight of carbon fiber 200 g per square meter and fabric B with a yarn density of the warp and weft of carbon fiber bundle the same as the abovementioned reinforced fiber 1.00/cm, the number of crossing points 10,000 per square meter in a flat structure, and the weight of carbon fiber 200 g per square meter, filled fabrics with a width of 100 cm were manufactured, by coating binder at the location of the center of the yarn width of the warp and/or weft, using low melting point copolymer nylon, low melting point polyester and polyethylene soluble in alcohol as binder, and glass fiber yarn ECE 225, 1/0, as the auxiliary yarn. These fabrics were rewound on a roll for 30 m each.

[0046]

As resin of wet prepreg process, phenol resin is used and with this as solvent A, solution diluted in methanol, solution diluted in MEK, and solution diluted in solvent mixed with MEK and methanol in the weight ratio of 90 : 10 were prepared. Resin dilution was adjusted so the resin weight content of prepreg would be about 40%, under the condition of the processing speed of prepreg at 2.5 m/min. The fabric type, binder type and combination of solvent used in the experiment are given in Tables 2 and 3.

[0047]

A solution diluted in solvent is placed in the resin bath installed at the bottom and into this resin bath, a rolled fabric is infiltrated by drawing out at the sped of 2.5 m/min. to impregnate resin between the fibers of fabric, and this is passed through the vertical type drying furnace attached with a rotating roll at the top at the height of 10 m. The fabric glued with solution is drawn up linearly to the rotating roll after passing through the resin bath, and hot air at the temperature A and B are

blown in the rectangular direction to the fabric surface from the wall of the upward movement side of fabric, drying the solvent to a certain degree, and then reversing the moving direction of the fabric by letting the fabric pass through the rotating roll, hot air at the temperatures C and D are blown in the rectangular direction to the fabric surface from the wall of the downward movement side to dry the remaining solvent. Then prepreg was rewound inserting a releasing paper. A separator was attached at the center of the vertical drying furnace in parallel to the fabric, so the drying temperature at the up side of fabric and processing side can be changed. The hot air temperatures are shown in Tables 1 and 2.

[0048]

This prepreg was passed through a calendar roll heated to 100℃ at the line pressure of 0.2 kg/cm and feeding speed of 1 m/min.

[0049]

The cover factor of prepreg after the abovementioned wet prepreg processing and calendar processing were completed were measured, of which results are shown in Tables 1 and 2.

[0050]

Table 1

		Example				
		1	2	3	4	5
Reinforcing fibre		Carbon fibre				
Number of filaments of reinforcing yarn		12,000				
Woven density (y/cm)	Warp	1.25				
	Weft	1.25				
Fibre area weight of woven fabric		200				
Number of crossing points (pieces/m^2)		15,630				15,300
Woven construction		Plain				
Cover factor of woven fabric (%)		97				
Low melting point binder polymer		Low melting point nylon				Low melting point polyester
Binder position		Warp and Weft	Weft	Warp and Weft		
Binder quantity (g/m^2)		1.4				0.8
Auxiliary yarn Type of auxiliary yarn		None -				
Resin type		Phenol resin			Epoxy resin	Phenol resin
Type of solvent Mixing ratio of solvent		MEK -		MEK/MeOH 90/10	MEK -	MeOH -
Boiling point of solvent		80		65	80	65
Hot air temperature: (C)	A	75		60	75	60
	B	75		70	80	70
	C	100		90	100	90
	D	100		90	100	90
Cover factor of prepreg (%)		95	94	96	95	
Cover factor of prepreg after calendar (%)		100				

[0051]

Table 2

		Example		Comparative example		
		6	7	1	2	3
Reinforcing fibre		Carbon fibre				
Number of filaments of reinforcing yarn		12,000				
Woven density (y/cm):	Warp	1.00		1.25	1.00	1.25
	Weft	1.00		1.25	1.00	1.25
Fibre area weight of woven fabric		200	160	200	160	200
Number of crossing points (pieces/m^2)		15,300	10,000	15,300	10,000	15,300
Woven construction		Plain				
Cover factor of woven fabric (%)		97	99	97	99	97
Binder polymer		PE	Low melting point nylon			
Binder position		Weft	Warp and Weft			
Binder quantity (g/m^2)		0.8	1.3	1.4	1.3	1.4
Auxiliary yarn		None	Warp	None	Warp	None
Type of auxiliary yarn		-	GF yarn	-	GF yarn	-
Resin type		Phenol resin				
Type of solvent A		MeOH	MEK	MeOH		MEK
Mixing ratio of solvent			-	-		-
Boiling point of solvent (C)		65	80	65		80
Hot air temperature (C)						
	A	60	75	60		90
	B	70	80	70		100
	C	90	100	90		100
	D	90	100	90		100
Cover factor of prepreg (%)		97	95	45	40	80
Cover factor of prepreg after calendar (%)		100	100	65	70	95

[0052]

From the abovementioned examples and comparison examples, the following things can be said.

A. When methanol soluble in low melting point nylon is used as a solvent, the flatness of weaving yarn gets crushed and the yarn width becomes thin, resulting in prepreg of a small cover factor (comparison examples 1 and 2). By using MEK, a solvent non-soluble to low melting point nylon, the cover factor of fabric prepreg becomes slightly smaller as compared with fabrics before prepreg processing, but despite this fact, prepreg with a high cover factor of 90% or higher was obtained. (Examples 1, 2, 4 and 7).

[0053]

B. Mixing about 10% of methanol, a solvent soluble in polymer used as binder, with MEK, a solvent insoluble in polymer can give filling effect, resulting in prepreg with a high cover factor of 90% or more was obtained. (Example 3)

[0054]

C. Even when the binder polymer is a low melting point polyester or polyethylene, the same effect as A was attained by using methanol, an insoluble solvent. (Examples 5 and 6)

[0055]

D. When the hot air temperatures A and B at the start of the drying process is raised higher than the boiling point of solvent, the flatness of weaving yarn is crushed and prepreg with a small cover factor of 80% is obtained (comparison example 3). However, by setting the temperature of hot air at 1/2 of the drying zone below the boiling point, prepreg with a high cover factor of 95% or more was obtained (Example 1).

[0056]

E. By putting prepreg through a calendar processing, the weaving yarn is widened and prepreg of cover factor of 94% to 97% is improved to 100%. Prepreg with the carbon fiber completely dispersed was obtained. (Examples 1 to 7).

[0057]

Effect of invention

As described above, with prepreg of a reinforced fiber fabric of this invention and its manufacturing method, even with a fabric of loosely constrained flat yarns, prepreg fabric with no gap between the yarns, and with uniformly dispersed fibers can be obtained, without the component yarns being crushed.

[0058]

Furthermore with the prepreg of this invention, because a thin prepreg is obtained with a thick reinforced fiber yarn, a low cost and light product can be obtained. Further because there is no void formed by gaps between the weaving yarn in the prepreg, and fibers are dispersed evenly, the mechanical properties of products is uniform and exerts excellent effect as interior material.

[Brief description of the drawings]

[Figure 1]

This is a partial plane figure of a reinforced fiber fabric for prepreg manufacturing of one implementation condition of this invention.

[Figure 2]

This is an overview vertical section of prepreg manufacturing process indicating one method of the prepreg manufacturing of this invention.

[Descriptions of Codes]

1. Reinforced fiber fabric
2. Warp
3. Weft

4 and 5. Binder

6. Resin bath
7. Solution
8. Rotation roll
9. Vertical drying furnace
10 and 13. Wall
11, 12, 14 and 15. Hot air blowhole
16. Separator
17. Releasing paper

[Document name] Summary

[Summary]

[Topic]

To obtain prepreg with a uniform fiber dispersion and large cover factor.

[Means of solution]

The manufacturing method of wet type prepreg of reinforced fiber fabric characterized in that a reinforced fiber fabric composed of twist-free, flat reinforced fiber with a yarn width of 3 to 20 mm and a ratio of yarn width to yarn thickness of 20 or above, the number of crossing points of the warp and weft 500 to 25,000 per square meter and the cover factor 90% or more, and follow the following procedures:

(1) a polymer binder is distributed line-like on the reinforced fiber fabric to glue the entire yarn width of the weft and/or warp,

(2) the relevant reinforced fiber fabric is infiltrated in a solution of thermosetting resin diluted with solvent A which is insoluble in the abovementioned polymer at least 80%,

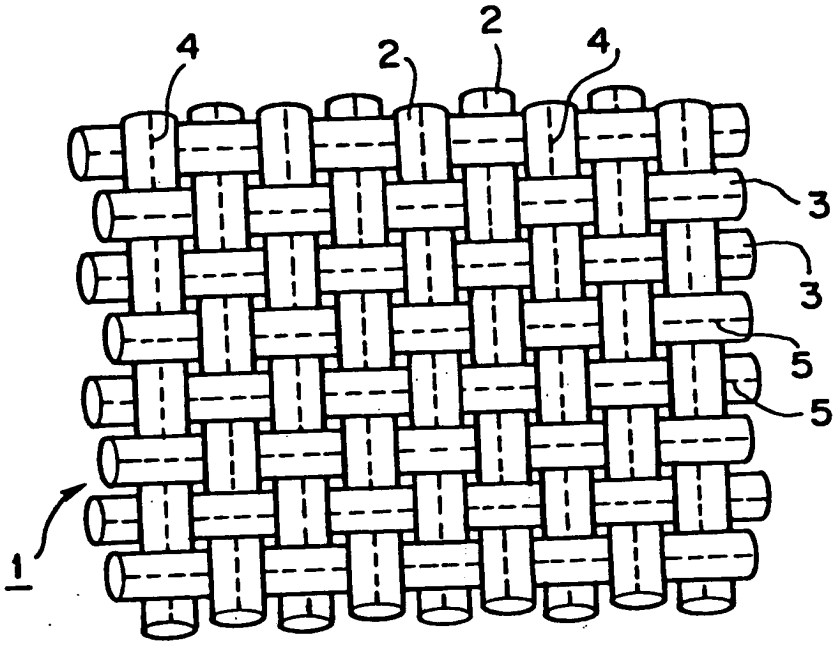
(3) then the solvent is dried by hot air.

[Selected drawing]

[Figure 1]

[Document name] Drawing

[Fig. 1]



[Fig. 2]